AD-A224 832

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SIMPLE APPROXIMATION FOR EFFECT OF ALLOYING
ON THE PHENOMENOLOGICAL LINEWIDTH Γ

Consider that $E_{cv}(\vec{k})$ is not a unique, sharply defined energy, but that for the absorption of a photon "locally", it depends on the local concentration c_{loc} averaged over a cluster of N atoms on the Hg-Cd sublattice.

$$E_{cv}^{loc}(\vec{k}) \approx E_{cv}^{loc}(\vec{k}_{cr}) + \frac{\hbar^2}{2\mu}(\vec{k} - \vec{k}_{cr})^2;$$

i.e., the dominant source of variation in $E_{cv}^{loc}(\vec{k})$ is the variation in the local critical point energy

$$E_o(c_{loc}) \equiv E_{cv}^{loc}(\vec{k}_{cr}).$$

Then, for $N >> 1$,

$$P(E_o) \approx (\sigma\sqrt{2\pi})^{-1} \exp\{-[E_o - E_o(c)]^2/2\sigma^2\}$$

with $\sigma^2 = E_1 \, c(1-c)/N$,

where $E(c_{loc}) \approx E(c) + (c_{loc} - c) E_1$.

This leads to a replacement of the lineshape

$$L(E,\vec{k},\Gamma_o) = -[E - E_{cv}(\vec{k}) + i\Gamma_o]^{-1}$$

by $\bar{L}(E,\vec{k},\Gamma_o) = -\int_{-\infty}^{\infty}\{E - E_{cv}(\vec{k}) - [E_o - E_o(c)] + i\Gamma_o\}^{-1} P(E_o) \, dE_o$

The only simple analytic result is obtained by replacing the Gaussian probability $P(E_o)$ by a Lorentzian probability. If one does this and chooses the Lorentzian probability to have width

$$\Gamma^1 = \sqrt{2}\sigma,$$

which follows from an expansion of e^{-u^2} as $[1 + u^2 + \ldots]^{-1}$, one finds that Γ_o is replaced by

$$\Gamma_m = \Gamma_o + \sqrt{2}\sigma = \Gamma_o + E_1\sqrt{2c(1-c)/N} + kT$$

This gives the following table:

$\Gamma-(\Gamma_o+kT)$	.04eV	.06eV	.08eV	.10eV
N	200	88	50	32

A better numerical approximation leads to values of N approx 40% larger.

PHYSICAL MEANING OF ΔE_1 and $\Delta \sigma^2$

$$\Delta E_1 \overset{\downarrow}{=} \Delta E_{cb} - \Delta E_{vb}$$

$$\Delta E_1 > 0 \quad \text{means} \quad \Delta E_{cb} > \Delta E_{vb}$$

$$\Delta E_1 = 0 \quad \text{means} \quad \Delta E_{cb} = \Delta E_{vb}$$

$$\Delta E_1 < 0 \quad \text{means} \quad \Delta E_{cb} < \Delta E_{vb}$$

TWO CAUSES FOR THE CONTRIBUTION

a - Piezoelectric effect in non-centrosymmetric materials.

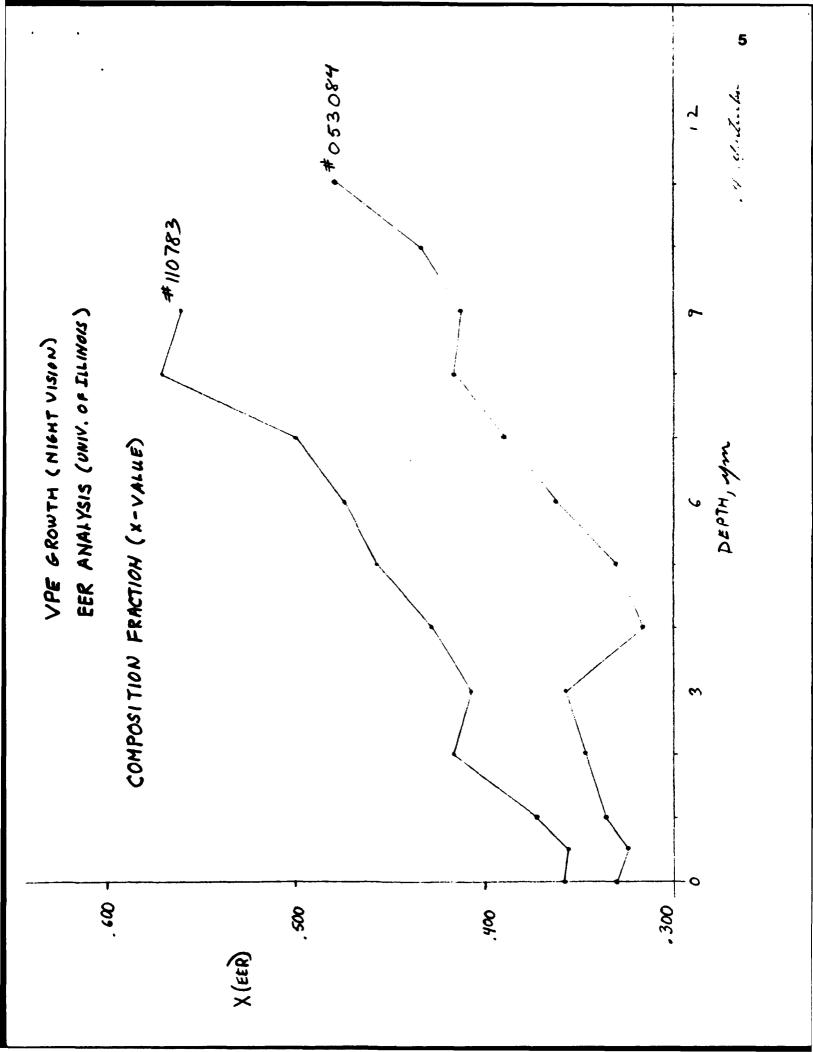b - Breakdown of symmetry induced by overlapping structural defects.

$\Delta \sigma^2$ is proportional to the density of polarizable defects is in first

approximation related linearly to ΔE_1

ELECTROLYTE ELECTROREFLECTANCE ANALYSIS
OF VARIOUS VAPOR PHASE EPITAXIAL GROWTHS
FROM NIGTH VISION.

GROWTH FACES- BOTH A AND B (111)
GROWTH SUBSTRATES-CDTE AND CDZNTE

NVL SAMPLES (DATA SUMMARY)

		#053084	#40284	#110783
SUBSTRATE :		CDZNTE (4.5%)	CDTE	CDTE
		$\langle 111 \rangle B$	$\langle 111 \rangle B$	$\langle 111 \rangle A$
GROWTH :		CSVPE	CSVPE	CSVPE
SOURCE :	TYPE	HGTE SINTERED	HGTE SOLID (4th USE)	HGTE PIECES
	COMP.	HGTE + 10% TE	47/53	1/1
	wt.	35 gm	50 gm	20 gm
TEMP :		540°C	540°C	545°C
TIME :		65 min.	55 min.	70 min.
ENVIRON. :		800 PSI, H_2	690 PSI, H_2	1100 PSI, H_2
EST. THICKNESS :		14 μm	12 μm	10.4 μm

VPE GROWTH (NIGHT VISION)
EER ANALYSIS (UNIV. OF ILLINOIS)

COMPOSITION FRACTION (X-VALUE)

#110783

#053084

X (EER)

.600

.500

.400

.300

DEPTH, μm

0   3   6   9   12

5

UNIV. OF ILLINOIS DATA

SAMPLE #110783

Etch Depth in Microns	C	ΔE_1	$\Delta \sigma^2$	θ	E_1	Γ	x
0	4.050	1.520	-2.090	4.817	2.431	.120	.358
.5	2.386	-0.974	-3.664	4.646	2.430	.129	.356
1	3.927	.947	-2.279	5.029	2.449	.148	.374
2	1.621	26.801	.941	6.071	2.497	.110	.417
3	1.430	10.810	4.423	6.901	2.486	.121	.407
4	1.706	-1.217	-3.178	4.901	2.509	.136	.428
5	1.070	26.770	-1.890	5.706	2.542	.113	.457
6	1.272	26.995	-1.679	5.737	2.563	.144	.474
7	1.036	10.217	1.050	6.467	2.595	.114	.500
8	3.859	-5.941	3.295	1.877	2.684	.227	.570
9	8.320	1.804	1.085	6.975	2.672	.204	.560

SAMPLE #053084

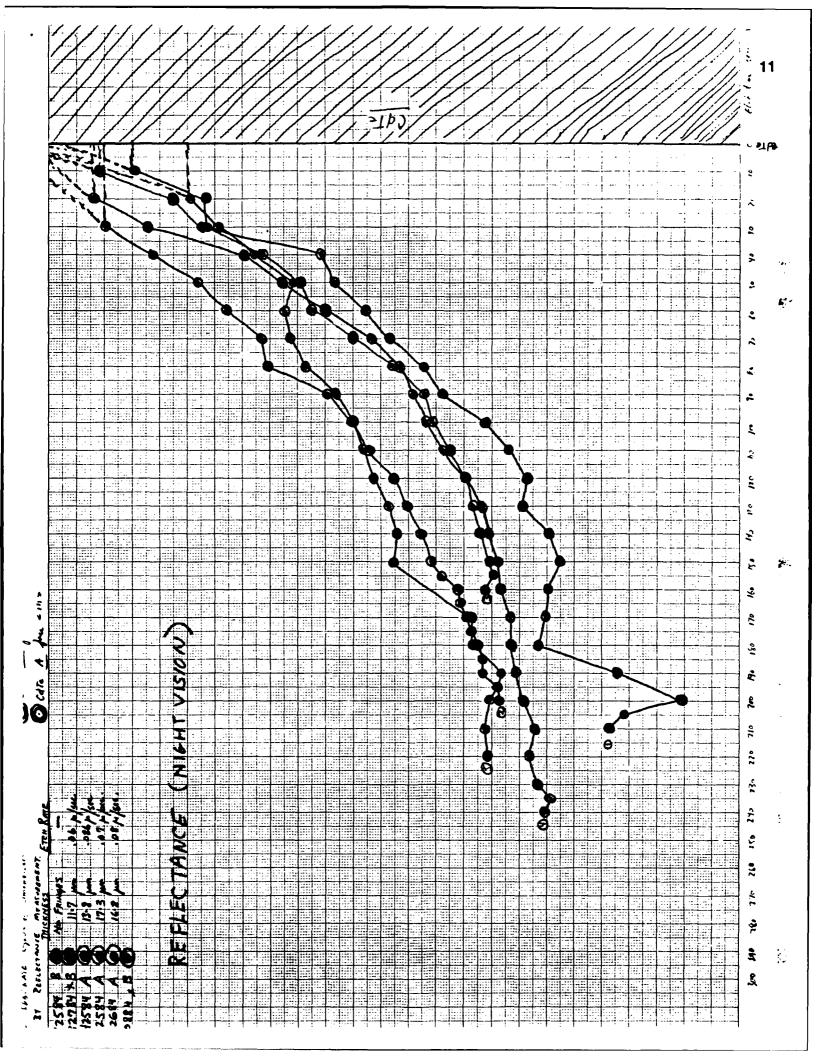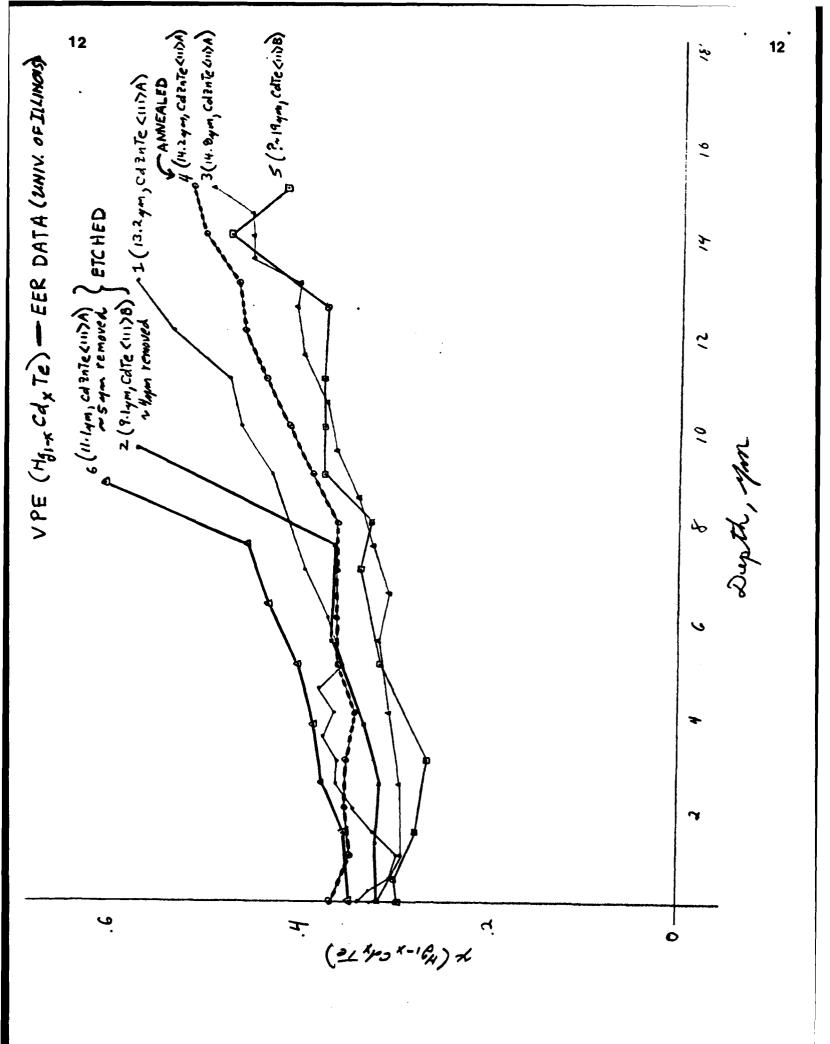| Etch Depth in Microns	C	ΔE_1	$\Delta \sigma^2$	θ	E_1	Γ	x
0	1.973	-65.548	4.571	5.624	2.404	.095	.331
.5	2.330	-5.796	3.449	4.771	2.397	.111	.324
1	1.788	-14.889	3.810	5.065	2.409	.104	.336
2	4.468	-3.100	1.256	4.585	2.420	.132	.347
3	2.004	-3.394	2.384	4.676	2.430	.116	.357
4	-.561	68.486	-5.404	5.496	2.389	.091	.316
5	-.521	39.402	-11.528	5.110	2.405	.096	.332
6	.633	-31.714	9.116	5.135	2.437	.097	.363
7	2.954	-2.548	2.149	4.640	2.468	.126	.391
8	1.638	-7.286	3.090	4.946	2.496	.116	.417
9	-1.070	18.478	-3.713	5.314	2.491	.111	.412
10	-.290	109.621	-4.101	5.642	2.515	.070	.434
11	-.248	67.353	-9.137	5.355	2.569	.103	.478

SAMPLE # 40284

HAD NO SIGNAL

COMPARISON OF REFLECTANCE (@NIGHT VISION) AND
ELECTROREFLECTANCE (@UNIVERSITY OF ILLINOIS)
ANALYSIS OF VAPOR PHASE EPITAXIAL GROWTHS
FROM NIGHT VISION.

GROWTH FACES- BOTH A AND B (111)
GROWTH SUBSTRATES-CDTE AND CDZNTE

NVL DATA

Begun 13 Dec 1984

SEE ATTACHED FOR EER RESULTS ONLY SEE FILE

SURFACE X, THICKNESS (μm) COMPARISON
BETWEEN EER AND REFLECTANCE SAMPLES

Remeasured by EER

#	NVL VPE	Crystalline / EER Sample	Reflectance Sample	Chop Trans Device Knob Dome Thickness	ΔX	ΔT (μm)	AT (μm)
1	101284 VERY GOOD FRINGES (CdZnTe <111A>)	.295 /3.2 .535	.286 14.1	(12.5 μm)	.009	.9	(.7)
2	032284 Good Fringes (CdTe <111B>)	.291 9.1 3.0	.275 10.8	(12 μm)	.019	1.7	(1.2)
3	052984 VERY Good Fringes (CdZnTe <111A>)	.284 /4.8 .316 3.5	.283 12.6	(13 μm)	.008	2.2	(.4)
4	102284 Good Fringes (CdZnTe <111A>)	.345, .313 /4.2	.182 16.6	(15 μm)	.057	2.4	(.8)
5	020284* Poor Fringes (CdTe <111B>)	.398 NO * .394 FRINGES	.300 16.3	(19 μm)	.002	—	(2.7)*
6	020484 Poor Fringes (CdZnTe <111A>)	.334, .337 /4.1 .350	.272 12.0	(11 μm)	.072	.9	(.1)

	102484G	020284	102384	052983	032784	101884	Comments
Melt Type	Sintered HgTe Powder 3rd use	Sintered HgTe Powder	Sintered 14% Te Powder	Sintered HgTe Powder + 10% Te by weight	HgTe	Sintered HgTe Powder 1E use	
Temp	555°C	540	545	540	540	550	
Time	45 min	90 min	50 min	70 min	60 min	55 min	
Spacing	1.0 mm	2.5 mm	2.5 mm	2.5 mm	2.5 mm	1.5 mm	what is proper spacing config?
Etching	110 sec /2 Br-MeOH (Standard)	NONE	*	NONE	95 sec 17% Br removed ~4μm	NONE	Etch note?
Melt Ratio	1/1 Atomic {90g	52% Hg {60g 48% Te {50g	1/1 Atomic {60g	1/1 Atomic HgTe {50g +2.5% Te wt	47% Hg {50g 53% Te {50g	1/1 Atomic {80g	effect of varying melt composition?
Substrate Prep	5% Br-MeOH Mech/Chem Polish 60 sec	Standard	Standard	Standard	Standard	5% Br-MeOH Mech/Chem Polish 60 sec	Recommend?
Back Surface X	CdTe (wt)	CdTe (at)	CdTe (at)	x = .723 (EEL) .60 (R)	CdTe (m) x = .644	CdTe (m) .644	020284!
Anneal	No	No	4 times, total 500 min at Yb ETCHED Each time	No	No	NO	why anneal? Finish guidances are required and annual

REFLECTANCE (NIGHT VISION)

	THICKNESS	No. FRINGES	ETCH RATE
2584 B		11.7	.06 µ/un
2584 *B		15.8	-.04 µ/un
2584 A		17.3	.07 µ/un
2584 A		16.2	.09 µ/un
2584 B			

VPE ($Hg_{1-x}Cd_xTe$) — EER DATA (UNIV. OF ILLINOIS)

ETCHED

6 (11.1 µm, CdZnTe⟨111⟩A) ≈5 µm removed

2 (9.1 µm, CdTe⟨111⟩B) ≈4 µm removed

1 (13.2 µm, CdZnTe⟨111⟩A)

ANNEALED
4 (14.2 µm, CdZnTe⟨111⟩A)

3 (14.8 µm, CdZnTe⟨111⟩A)

5 (?.19 µm, CdTe⟨111⟩B)

Depth, µm

$x (Hg_{1-x}Cd_xTe)$

.6

.4

.2

0

2 4 6 8 10 12 14 16 18

Received 1 May 85

1 NVL-VPE 171884

D (micron)	E_1 (ev)	X	Γ (ev)	$\frac{\Delta E_1}{(\hbar\Omega)^3}$ (eV^{-2})
0	2.408	0.335	0.123	18.5
0.25	2.398	0.325	0.110	22.1
0.5	2.376	0.303	0.146	10.2
1.0	2.369	0.296	0.141	4.1
1.5	2.394	0.322	0.138	3.3
2.0	2.416	0.343	0.157	1.6
2.5	2.433	0.359	0.126	4.1
3.0	2.432	0.358	0.107	20.5
3.5	2.449	0.374	0.117	5.1
4.0	2.438	0.363	0.115	-3.0
4.5	2.453	0.378	0.098	29.0
5.0	2.428	0.354	0.148	11.8
6.0	2.444	0.370	0.126	23.4
7.0	2.472	0.395	0.125	16.3
9.0	2.512	0.430	0.121	18.4
10.0	2.551	0.464	0.134	5.8
11.0	2.567	0.477	0.105	53.5
12.0	2.642	0.537	0.143	8.3
13.0	2.671	0.574	0.154	10.2
14.0				

2 NVL - VPE 032784

D (micron)	E_1 (ev)	X	Γ (ev)	$\frac{\Delta E_1}{(\hbar\Omega)^3}$ (eV^{-2})
0	2.368	0.315	0.142	-0.20
1.25	2.371	0.318	0.124	-0.60
2.50	2.387	0.314	0.124	-5.65
3.15	2.404	0.331	0.130	-2.46
5.50	2.440	0.366	0.112	-14.66
7.50	2.437	0.363	0.111	47.61
9.50	2.690	0.574	0.097	0.10
10.00				

3   NVL VFE 05=934

D (micron)	E_i (ev)	X	Γ (ev)	$\frac{\Delta E_i}{(\hbar\Omega)^3}$ (eV^{-2})
0.0	2.388	0.316	0.124	14.9
1.0	2.364	0.292	0.113	-3.5
2.5	2.367	0.294	0.110	-3.1
4.0	2.378	0.306	0.108	-3.2
5.5	2.372	0.319	0.109	-3.2
6.5	2.380	0.307	0.107	-6.0
7.5	2.395	0.323	0.110	-4.3
8.5	2.412	0.337	0.115	-3.9
9.5	2.438	0.363	0.135	-21
10.5	2.448	0.373	0.135	-2.4
11.5	2.475	0.373	0.129	-3.2
12.5	2.482	0.405	0.117	-5.3
13.0	2.481	0.403	0.113	-7.4
13.5	2.537	0.452	0.135	-2.8
14.0	2.538	0.453	0.124	-4.1
14.5	2.539	0.454	0.118	-4.2
15.0	2.591	0.497	0.153	-0.3

4   NVL-VPE   102384

D (micron)	E_1 (ev)	X	Γ (ev)	$\dfrac{\Delta E_1}{(k\Omega)^3}$ (eV^{-2})
0	2.440	0.365	0.124	5.4
1.0	2.418	0.345	0.120	-1.8
2.0	2.4=6	0.352	0.122	-1.8
3.0	2.423	0.350	0.124	-1.2
4.0	2.422	0.340	0.118	-1.5
5.0	2.431	0.358	0.118	-1.7
6.0	2.435	0.361	0.121	-0.6
7.0	2.436	0.362	0.123	-1.1
8.0	2.435	0.361	0.123	-3.8
9.0	2.464	0.388	0.149	0.5
10.0	2.492	0.413	0.130	-1.1
11.0	2.520	0.438	0.107	31.5
12.0	2.548	0.461	0.100	44.7
13.0	2.556	0.468	0.115	28.2
14.0	2.600	0.504	0.161	5.5
15.0	2.617	0.517	0.174	6.5
16.0				

5 NVL - 020884

D (micron)	E_i (ev)	X	Γ (ev)	$\frac{\Delta E_i}{(\hbar\Omega)^3}$ (eV^{-2})
?	2.360	0.295	0.127	-0.05
0.5	2.371	0.278	0.077	-127.5
1.5	2.347?	0.276	0.127	0.02
3.0	2.334	0.265	0.093	47.25
5.0	2.387	0.314	0.101	-20.33
7.0	2.411	0.338	0.102	-69.07
8.0	2.401	0.328	0.130	2.18
9.0	2.451	0.376	0.109	-67.98
10.0	2.451	0.376	0.099	-85.57
11.0	2.454	0.378	0.115	-2.78
12.5	2.449	0.374	0.105	140.93
14.0	2.565	0.476	0.135	-42.56
15.0	2.479	0.419	0.104	53.54
17.0				

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NVL-VPE 102424

D (micron)	E_1 (ev)	x	Γ (ev)	$\frac{\Delta E_1}{(k\Omega)^3}$ (eV⁻¹)
0	2.416	0.342	0.124	-2.32
1.25	2.425	0.351	0.116	-3.85
2.50	2.449	0.374	0.127	-3.61
3.75	2.459	0.383	0.115	-5.90
5.00	2.479	0.402	0.117	-5.40
6.25	2.516	0.434	0.123	-4.46
7.50	2.542	0.456	0.125	-2.30
8.75	2.735	0.607	0.151	-23.59
10.00				